

# How to Make Phosphorus

*Phosphorous was invented by accident by alchemist Hennig Brandt In 1669, while trying to make a philosopher's stone (a mythical substance which could turn base metal into gold). Since the time of Brandt, newer methods for producing phosphorus have been discovered, but they require much higher temperatures and more sophisticated equipment than the average individual possesses. This article will describe how to make phosphorous the old-fashioned way.*

## Things You'll Need

- Urine
- Charcoal dust
- Cinnamon powder

Glass retort Glass container Water Eye protection Breathing mask Gloves Butane torch Tripod for glass retort Show (8) More

## Instructions

### 1. How to Make Phosphorus

○ 1

Allow urine to sit in an open container for 7 days.

○ 2

Mix two tablespoons of finely-powdered charcoal and two tablespoons of powdered cinnamon into the urine and stir.

○ 3

Pour the urine/charcoal dust and cinnamon mixture into a glass retort with a glass tube leading into a second beaker filled with plain water.

○ 4

Heat the retort containing the urine mixture using your torch. Be sure to wear protective clothing, eye protection and a breathing mask.

o 5

Allow the vapors from the urine mixture to bubble through the plain water. A yellow or white waxy substance will collect in the bottom of your water beaker. This is phosphorous. Do not expose it to the air or it may ignite spontaneously. After being exposed to light your phosphorous should glow very brightly in the dark for several hours.

## Tips & Warnings

- Over time your white phosphorous will change into a red phosphorous if left in your water-filled beaker. Once it has changed into a red color it should be more stable in the air but still needs to be handled with care.
  - White or yellow phosphorous should not be removed from its water-base unless you are prepared for it to spontaneously catch fire upon exposure to the air.
- 

## How to Obtain Red Phosphorus



The strike face of matches contains red phosphorus.

*Red phosphorous is an allotrope of elemental phosphorous and has many uses. Highly flammable, it is a component of both matches and pyrotechnics, and it has military applications in the form of tracer rounds and incendiary munitions. Red phosphorus has gained the attention of law enforcement due to its function in producing illegal methamphetamine. It is obtained from white phosphorus by heating the latter substance to a temperature of 482 degrees F, according to a 2005 lecture by Professor Yihui Yang at*

*the University of Tennessee, Knoxville, that is published on the Internet. White phosphorus is highly toxic, and the production of red phosphorus is a delicate operation best left to professionals.*

## Things You'll Need

- Airtight container with airlock Vacuum pump Immersed white phosphorus Heating mechanism

Show More

## Instructions

1.

○ 1

Remove all air from an airtight container using a vacuum pump.

○ 2



White phosphorus explodes if it comes into contact with air.

Transfer immersed white phosphorus into the airlock. When you do this, ensure that all air is forced out of the airlock to avoid an explosion.

○ 3

Move the immersed white phosphorus from the airlock into the airtight container. Do this without breaking the external airlock seal.

○ 4

Heat the airtight container to at least 482 degrees F. The white phosphorus will slowly change into red phosphorus. When the entire sample of phosphorus turns from a white color to a deep red, the process is complete.

## Tips & Warnings

- Red phosphorus is stable in air, and can be transported safely without immersion in water. The California Environmental Protection Agency indicates, however, that the substance is still toxic and should be handled carefully. Either a heating element or focused sunlight can be used to heat the airtight container to the necessary temperature.
  - White phosphorus is extremely reactive and spontaneously combustive in air. It must be continuously immersed in water. Take extreme care to ensure white phosphorus never comes into contact with air. White phosphorus is extremely toxic. If exposed, seek medical attention immediately. Due to the danger of using white phosphorus, the production of red phosphorus should occur only under controlled circumstances by experts in handling phosphorus. Law enforcement agencies in many regions keep a close watch on red phosphorus because of its use in making methamphetamine. Contact law enforcement for information on laws and ordinances regarding the transport or use of phosphorus compounds.
- 

### Organic sources for phosphorus

Other than bone meal or the creative use of phosphoric acid in coke, what are some other organic sources of phosphorus? It seems like it's much more difficult to come by compared to nitrogen or potassium sources

Bone meal and rock phosphate are typical sources. If you can find them, fish bone meal and soy husks are other good sources. And then there is compost :-). Composted yard waste and manures generally provide all the phosphorus normally required by most plants in most soils and if applied in excess, can create an oversupply.

Some food sources have pretty high levels of phosphorus naturally - banana peels, crab shells, shrimp peelings, most grains and nuts - and these should all be added to compost when available. Meats, poultry, eggs and dairy products are also phosphorus-rich, but you'd want to avoid adding those to your compost.

I like using crushed coral, it's a high P rock that also breaks down slowly (like rock phos) but is a healthy/more balanced source, it also provides natural salts and other trace minerals that serve as micro nutrients. Also depending on how fine it's crushed, it aids in creating a well draining soil consistency.

Use rock phosphate while it's available and not prohibitively expensive. The price spike

that happened in 2008 will happen again and worse. This is a mineral that's reaching peak production, just like oil. As it becomes scarcer, more expensive sources will be mined and the price will skyrocket. In the long run there's an answer for small-scale growers: urine, and I'm serious and sober. Regards, Peter.

Phosphate fertilizers, used judiciously, are much safer for the garden and the environment than coca cola.

Organic sources are hard to find because pound for pound, plants use much less P than N or K.

Personally, I also think that the 'organic' aspect of bone meal is debatable, given the environmental impacts of factory farming. Then again, it's just a byproduct so perhaps it doesn't make a difference.

Just wanted to point out that as far as the environment is concerned, 'organic' is not a silver bullet.

Hi, I have a small herd of sheep/goats and horses on one particular pasture that is in need of a rest and possibly some nutrients. It gets lots of manure and I was told I should put phosphorus on it. I have been told that the plants will absorb the phosphorus so there won't be any residue. Then I looked up organic ways to get phosphorus and found that bone meal may do it. Does anyone know how bone meal works. Do you put it on, let it rain and then animals can go back on it? Does bone meal also have a high nitrogen content that may not allow animals to graze on it straight away? How much does one put on - I would be spreading by hand over 3-4 acres. Any other side effects of bone meal? Anyone have experience with tired fields and chemical phosphorus? thanks, take care, mary

As usual, I forgot there is no edit function here. My mistake.

Egg shells have some phosphorus in them. And, as stated, rock phosphate has alot.

Why don't you want to buy some bone meal?

my suggestion:

buy some tribasic sodium phosphate. it is sold as TSP or trisodium phosphate, a strong cleaning agent, at many stores. finely grind some charcoal and intimately mix this, some sand and the TSP. put this in a makeshift furnace. i suggest you pump in a bunch of argon or helium to prevent oxidation. you'll need to heat this mixture thermite-style i suppose. figure out a way to heat it without burning things because if you CAN burn things your phosphorus will immediately oxidize upon formation. the phosphorus you produce will be quite hot and gaseous, so you'll probably want

something to trap it as it escapes, perhaps liquid nitrogen or something of the sort. a graham condensor or something similar would work a charm depending on how much you're making. just be careful not to have any oxygen coming in because if you do, you are, for all intents and purposes, screwed. white phosphorus gas oxidizing in the air is no fun whatsoever.

## **Phosphorus: fire from urine**

### **1. The discovery and production of phosphorus**

Civilisation would have been impossible without the discovery, taming and use of fire. Some historians would consider evidence of the use of fire as the mark of civilisation. The cooking of food widened food supplies and made food more nutritious; fire enabled the making of the first 'chemical' products - such as soap, and enabled metals to be obtained from rocks, as were glass and pottery. These developments are the hallmarks of civilisation and without fire they were and are impossible. Fire was also used for heating, enabling people to survive hard winters and to colonise more extreme climates, and to keep off predators. Thus the making of fire and keeping the fire in became vital tasks, without which vulnerable early societies would have perished. Starting a fire was a skilled and non-trivial task right up until the beginning of the 19th. century, and yet today we give it no thought. Why not? Because we expect to be able to 'strike a light' anywhere at any time using a match or nowadays, a butane gas lighter.

Put 21st. century man on an island or in a jungle without matches or a lighter and watch them struggle to create fire! We have lost the traditional skills of flint and tinder, of a friction stick, or one of the other time-honoured methods. It would now take us a long time, much experimentation (and even then we might well fail) to produce a flame. We would give anything for a simple box of matches, that humble, unsung product of the chemist and the chemical industry that has revolutionised everyday life around the world. How many times have you needed a light today - for the fire, the cooker or (unfortunately) a cigarette? We would be lost without a box of matches or a lighter, and none of us could make either of them from scratch! In this series of articles I want to trace the history of phosphorus and the friction match, and the contribution the chemical match has made to our comfort. Sadly, no matches are made any longer in the United Kingdom or Ireland - in Ireland Maguire & Patterson stopped manufacture in 1982 and in the U.K. Bryant & May closed its last match factory in 1997. The matches we buy now are made in Sweden or perhaps China (who seem to make almost everything these days). The match factories closed because of the competition from the disposable lighter, that awkward creation of plastic, metal and butane which as often as

not burns one's fingers as one tries to light something. But its convenience has almost killed off the humble match, that matchless triumph of applied chemistry.

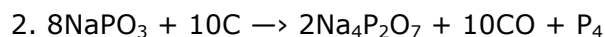
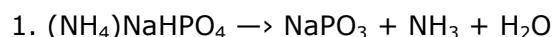
### **The burning brand - Brand discovers phosphorus!**

The story of the match goes back to the discovery of phosphorus by Hennig Brand (or Brandt) in 1669, immortalised in the painting by Joseph Wright of Derby (see page 58) and is one of the many legacies to civilisation of that despised domestic product, urine.

*"More than 300 years ago, in 1669, Hennig Brand, a Hamburg alchemist, like most chemists of his day, was trying to make gold. He let urine stand for days in a tub until it putrefied. Then he boiled it down to a paste, heated this paste to a high temperature, and drew the vapours into water where they could condense - to gold. To his surprise and disappointment, however, he obtained instead a white, waxy substance that glowed in the dark.*

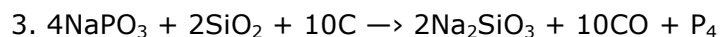
*Brand had discovered phosphorus, the first element isolated other than the metals and non-metals, such as gold, lead and sulphur, that were known to the ancient civilisations. The word phosphorus comes from the Greek and means light bearer."<sup>1</sup>*

Brand (also known as Dr. Teutonicus) evaporated urine and so produced ammonium sodium hydrogenphosphate (microcosmic salt), which on heating produces sodium phosphite. When heated with carbon (charcoal) this decomposed to produce white phosphorus and sodium pyrophosphate.



Brand's discovery was an accident but his discovery of phosphorus mirabile would turn out to be more valuable than gold in the future, for this 'cold fire' would enable inventors to produce fire on demand, an unimaginable achievement to Brand's contemporaries. Brand had tried to keep the method secret but he had sold the 'secret' to the German chemist, Krafft, who showed off the new wonder substance around the courts of Europe where Robert Boyle saw it in London. The secret that it was made from urine leaked out and first Johann Kunckel in Sweden (1678) and later Boyle in London (1680) also managed to make phosphorus.

Robert Boyle had seen samples of Brand's phosphorus exhibited in London and he eventually worked out a method to make phosphorus from urine in 1680, improving on Brand's process by using sand.



Notice that Boyle's improved method (eqn. 3) liberates all the phosphorus in the sodium phosphite. One of Boyle's assistants, Ambrose Godfrey Hankewitz, later set up in business making the new, wonder material. He charged 50/- an ounce for this new scientific curiosity. Robert Boyle was the first to use phosphorus to ignite sulphur-tipped wooden splints, forerunners of our modern matches, in 1680.

Boyle called the material 'icy noctiluca' (cold light) and examined its properties in a systematic way, which Brand and co-workers had not. To them it was just an interesting and profitable curiosity. Interestingly white phosphorus became known as English or Boyle's phosphorus to distinguish it from other luminescent materials, which were all called 'phosphorus'. Over the years these other names have vanished leaving only elemental phosphorus. In 1769 J.G. Gahn and C.W. Scheele<sup>2</sup> showed that calcium phosphate ( $\text{Ca}_3(\text{PO}_4)_2$ ) is found in bones and obtained phosphorus from bone ash. Lavoisier recognised phosphorus as an element in 1777. Bone ash became the major source of phosphorus until the 1840s. Phosphate rock, a mineral containing calcium phosphate, was first used in 1850 and following the introduction of the electric arc furnace in 1890 this became the only source of phosphorus. Phosphorus, phosphates and phosphoric acid are still obtained from phosphate rock. A major use for phosphate rock is for making phosphate fertilizers (but that's another story.)

### **Albright and Wilson**

Albright & Sturges started making phosphorus in the UK in 1844 and are still one of the major world producers of phosphorus chemicals<sup>3</sup>. The company, located at Oldbury in the 'Black Country', was founded by Arthur Albright (1811-1900), a Quaker. The Quakers, a nonconformist Christian group, became very influential in business and industry in the 18th. and 19th. century, partly because they were prevented from entering traditional occupations<sup>4</sup>. At 16 Arthur was apprenticed to a chemist-and-druggist uncle in Bristol, the start of many a chemical career in the 19th. century. In 1840 he became a partner in the firm of John & Edmund Sturges of Birmingham, manufacturing chemists, and in 1844 he persuaded his partner to start making phosphorus, then coming into use for making matches. It cost 5/- a pound and most of it was imported. The raw material was bone ash, imported from South America and later from eastern Europe. The first factory was in Selly Oak, Birmingham. The company moved to Oldbury and erected a new factory in 1850, and the first phosphorus was made at Oldbury in 1851. Oldbury was already a centre of chemicals, with local supplies of coal and a good canal and rail transport system. A contemporary writer, Walter White, wrote in 1860 of a visit to Oldbury:

*"Among the chimneys rise those of a phosphorus factory, where, at some risk, and at a fierce temperature, phosphorus is extracted from bones, in such quantities that England, which used to import, now exports the article, sending many tons to Vienna and receiving it back on the end of matches by hundreds and millions every week. One pound of phosphorus, worth about two-and-nine-pence, suffices to charge a million of matches."*<sup>5</sup>

Albright said that he thought of making phosphorus because Sturges was already supplying the 'twin sister' of phosphorus used in matches, namely chlorate of potash ( $\text{KClO}_3$ ). He thought he could make it cheaper than on the Continent because of the good supplies of cheap coal in the Black Country. At first the price of



phosphorus was 7s.6d. a lb, but this came down to 6d. a lb. by the 1880s, as the economies of scale started to produce fruit. England became by 1860 a net exporter of phosphorus. The partnership with Sturges was dissolved in 1855 and in 1856 John Edward Wilson (another Quaker) joined Albright in partnership and the firm was incorporated as Albright & Wilson in 1856. He supplied the administrative acumen to support Albright's chemical genius: *"if Arthur struck the spark, John Edward blew it to a flame; and it was his wise and constant tending that kept it burning ever more brightly."*<sup>6</sup> Wilson ensured that the new company was run profitably with as little waste as possible, so that it survived and prospered while 25 other phosphorus works opened and closed in Oldbury in as many years.

Initially the raw material for phosphorus production was animal bones, later replaced by mineral phosphates. The bones or rock were dissolved in sulphuric acid to give phosphoric acid and calcium sulphate as a by-product. The acid was concentrated, mixed with 25% of its mass with carbon, dried in iron pots to a black powder and then distilled in clay retorts. Phosphorus distilled over and was condensed into 25-30 lb. blocks called 'cheeses'. After refining and casting into sticks (all under water to prevent it catching fire), the product was shipped, again under water, to the end users. In the 1890s this original batch process was superseded by the continuous electrothermic process. Cheap electricity rather than coal was now the key to cheap phosphorus and by 1920 production had ceased at Oldbury and Albright & Wilson transferred their production to Niagara Falls, in the USA and Canada.

As soon as Albright heard of Schröter's discovery of the safer red phosphorus in 1844 he bought the patent and started to develop a safe production process. He was successful and the Oldbury works started making red (or amorphous) phosphorus in 1851 by heating white phosphorus at a controlled temperature in a closed iron pot. The problem of making reliable matches using red phosphorus was yet to be solved, but eventually Albright's efforts to make a safer form of phosphorus was to protect the health of match makers around the world. Production of red phosphorus did not expand until a successful safety match was invented (see part 2).

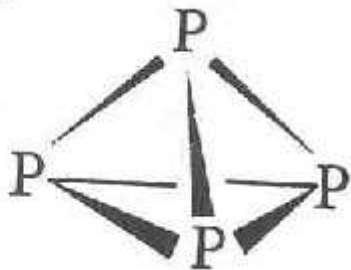
### **White, red and black: allotropes of phosphorus**

Phosphorus is one of the non-metals that shows distinctive allotropy: different forms of the same element but with different physical and chemical properties. There are three common forms of phosphorus: white (or yellow), red and black. In all of them the P atoms are joined together by three single bonds, but in different ways. White P is a molecular solid composed of P<sub>4</sub> tetrahedral molecules (tetraphosphorus), with highly strained single bonds. These molecules are held together by only weak intermolecular bonds and this white P has a low mpt. and bpt. and is very reactive. It catches fire spontaneously in air (and must therefore be stored under water) and its vapour causes the dreaded 'phosphy jaw' which bedevilled early matchmakers. White P turns yellow

due to the slow formation of red phosphorus.

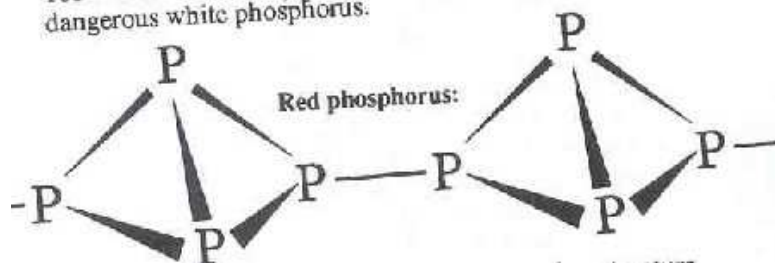
yellow due to the ...

White phosphorus:



Red P has a different structure based on puckered sheets of phosphorus atoms, each bonded to three other P atoms, with the sheets bonded to each other by van der Waal's forces. The mpt. and bpt. of red P are much higher than for white P (see table) and it is thus less reactive with air and safer to handle. In 1845 Schrötter of Vienna showed that white phosphorus could be converted to the less reactive and less toxic red phosphorus by careful heating. Albright started to manufacture in England in 1851 after obtaining a patent as a substitute for the dangerous white phosphorus.

1851 after obtaining a patent for the dangerous white phosphorus:

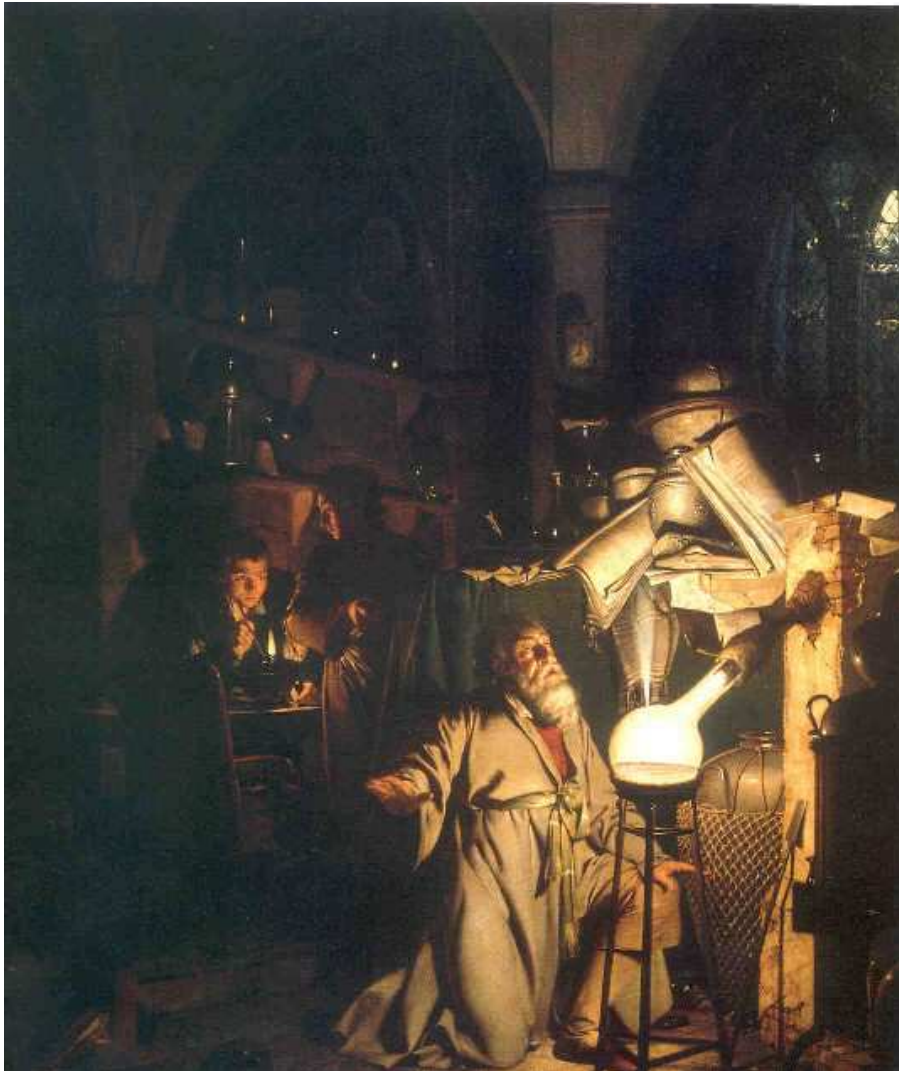


Black P has a similar but more complex structure differing in the structure of the puckered sheets.

### References:

1. A.D.F. Toy and E.N. Walsh, Phosphorus chemistry in everyday living, 2nd. ed. (Washington: ACS, 1987) p.1
2. M. Weekes, The Discovery of the Elements, 7th. edition, (Easton, Pa: J. Chemical Education: 1968) ch.31.
3. R.E. Threlfall, 100 Years of Phosphorus Making, (Oldbury: Albright & Wilson, 1951)
4. See the book by Arthur Raistrick Quakers in Science and industry (Bannisdale Press, 1950 ) for an account of their contributions.
5. Walter White, All Round the Wrekin, Chapman and Hall, 1860 quoted in Threlfall p. 39.
6. Threlfall, *ibid*, p. 45

Since I started collecting material for the history of phosphorus and matches, a new book by John Emsley has been published on **The Shocking History of Phosphorus**. This is an excellent book and well worth buying as it tells a fascinating, though sometimes gruesome story and is excellent value for money. See the review below. The second part of this article will look at the history of the match itself, that ubiquitous but overlooked triumph of chemistry.



'The Alchemist' by Joseph Wright (1771 and 1795), reproduced by courtesy of Derby City Art Galleries

okay so in your urine you have P (phosphorous ions) in solutions  
these ions are negatively charged as well as other -ions like chlorine etc.  
you can get the ions out of solution by electrolysis like you mentioned before. coulomb's law says that  
to opposite charged particles will attract so you will find your - ions like phosphorous on your + terminal.  
so now you need to get just phosphorous and not stuff like chlorine etc.

take that + terminal out of the water and empty it into a tray.  
place that tray into an oven at 350 F and all elements but phosphorous  
will boil off since P will have higher enthalpy of vaporization.